Light and Lighting

XXXIV.—No. 1 January, 1941 Price 9d

INCORPORATING "THE ILLUMINATING ENGINEER"

Incorporating "The Illuminating Engineer."

Light and Lighting

Official Journal of the Illuminating Engineering Society.

32, Victoria St., London, S.W.1.

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Telephone: ABBey 5215

Vol. XXXIV.—No. 1

January, 1941

PRICE NINEPENCE
Subscription 10/6 per annum, post free

Principal Contents:

Vision and Reality

IT used to be said that "The Camera Cannot Lie." Nowadays we know better, but we are still too apt to assume that "The Photometer Speaks the Truth."

So it does perhaps, in the main, at normal illuminations and in everyday life—but not always at the very weak order of illumination now permitted out of doors. Dr. Walsh in a recent admirable article in this journal ("The Reds and the Greens," Oct., 1940, p. 162) quoted Pilate ("What is Truth?") One might reinforce this quotation from Bret Harte ("Are Things What They Seem—or is Visions About?").

Certainly measurement and observation are difficult to reconcile in dealing with very weak coloured light. But even with white light—and to some extent throughout the whole range of brightness visible to the human eye—one's judgment of the brightness of any visible object is liable to be influenced by the brightness of an adjacent one. It is common knowledge that the apparent brightness of the first may be depressed by the greater brightness of the second—or even by the greater brightness of some object seen a short time previously but now no longer present. Expressed in technical terms:—Subjective Brightness, in contrast to the brightness measured by a photometer, depends on the state of adaptation of the eye.

The proceedings at the last two I.E.S. meetings (see pp. 4 & 5), when Mr. Waldram and his colleagues illustrated the effects of contrast, and when Dr. Wright discussed the preparation of a scale of values relating physical brightness to apparent brightness, have an intimate bearing on this problem.

The subject is difficult and intricate. In a sense Vision may be more vital than Reality. But let us go on exploring, for this paradox is of fundamental importance in its bearing both on war conditions and on the illuminating engineering of the future.

Vision in Very Weak Light

The proceedings at the I.E.S. meeting on January 14 formed a fitting sequel to the discussion on contrast initiated by Mr. Waldram and his colleagues on December 10. We deal elsewhere with this topic (pp. 4-5). The chief item was Dr. Wright's paper, with its suggestion of a new unit of subjective brightness (the "brill") and the demonstration of his brillmeter and apparatus for testing defective night vision. The opportunity was also taken, however, to discuss the report on the fundamentals of War-time Street Lighting, formally presented at the previous meeting. In this connection a series of simple demonstrations of effects at varying illuminations down to 0.0002 ft.c., was staged by Mr. J. S. Dow. Examination of Dr. Wright's paper shows that it contains fundamental data which form a necessary basis of some of the chief conclusions reached in the report. His methods are evidently specially well adapted to the study of contrast, effects of glare, adaptation, and night vision. It is interesting to learn that about 5 per cent. of people require nearly four times the normal standard of brightness when their eyes are operating in very weak illuminations—a manifest disadvantage in certain war-time occupations. Mr. Dow's experiments illustrated well the relation between size of object and apparent brightness in twilight vision, the degree of visibility obtainable at 0.2, 0.02, 0.002, and 0.0002 ft.c., and the prejudicial influence thereon of glare from luminous signs and traffic crosses of undue brightness. They were also helpful in bringing out one very important point—the extreme invisibility under these conditions of people in dark clothing, even when the background is of relatively high reflecting power.

I.E.S. Meetings of Local Centres

Hostile visitations to certain I.E.S. local centres have inevitably interfered with programmes. In some instances meetings have been cancelled or postponed, though it is to be hoped that the interruption is only temporary. We are glad to be able to record, however, the very successful meeting held in Glasgow on December 18, when the President repeated his address on "The Arc as a Standard of Light." Another London item was repeated at the meeting of the North Western Local Centre on November 14, when the paper on "The Photometric Properties of Luminescent Materials," by W. E. Harper, Margaret B. Robinson, and J. N. Bowtell was read. Despite somewhat unfavourable conditions this, too, attracted quite a good audience. The society's warmest thanks are due to those who undertake such journeys, and attend to the transport of apparatus, in present circumstances. A subsequent meeting of this Centre on December 12 was devoted to a series of short papers embodying local effort. This was a particularly successful gathering, and we hope shortly to present illustrated summaries of the papers read.

"Colour Group" Meeting, February 12

The attention of I.E.S. members is drawn to the above meeting, to take place at the Polytechnic, Regent-street, London, W.1, at 2 p.m. The I.E.S. is amongst the societies linked with this effort, which the Physical Society has initiated, and members interested are invited to attend. The first part of the meeting will be concerned with the draft constitution of the group, after which there will be a discussion on "Colour Tolerance." An introductory address will be given by Dr. W. D. Wright, after which there will be short papers on the commercial, technical, and physical aspects by Mr. Wilson (British Colour Council), Mr. Ellis (Clayton Aniline Company, Ltd.), and Mr. Perry (Adam Hilger, Ltd.). Further details may be ascertained from the honorary secretary of the Colour Group (Mr. H. D. Murray, 1, Lowther-gardens, Exhibition-road, London, S.W.7).

The constituent societies interested in the Colour Group are now: The British Kinematograph Society, The Illuminating Engineering Society, The Institute of Physics, The Physical Society, The Royal Photographic Society, The Society of Dyers and Colourists, and the Society of Glass Technology. The Illuminating Engineering Society has common interests with all these bodies and has organised joint meetings with most of them from time to time. That there are many intricate and difficult questions in connection with colour still awaiting solution is common knowledge.

Christmas Greetings from the Australian I.E.S.

The following exchange of greetings by cable has recently taken place between the Illuminating Engineering Societies in London and Australia:—

> *"In conveying Christmas Greetings we express the highest admiration courage and resolution everyone at home and sympathy with those who have suffered. Continue to rely our wholehearted support and maximum effort.*
>
> *"Illuminating Engineering Society, "Melbourne, Adelaide, Sydney."*

> *"In cordially reciprocating Christmas greetings we express deep appreciation message of sympathy and encouragement from Illuminating Engineering Society Australia. We have watched with admiration magnificent contribution Australia to common cause which is encouragement and inspiration to all in the mother country.*
>
> *"Illuminating Engineering Society, London."*

It was a happy thought of the various sections of the Australian Illuminating Engineering Societies jointly to convey this sympathetic and encouraging message, which all members here will deeply appreciate.

Lighting for Obscurity

The alleged advantages and drawbacks of the black-out have been the subject of much discussion ever since the war started. Many people have asked themselves—or asked each other—whether such dense obscurity is really worth while. This point is raised in an instructive form in the "K.-H. News-letter" issued by Commander Stephen King-Hall, M.P. If enemy machines are able to navigate to a selected spot by means of instruments or radio-beams the black-out would not prevent them fixing their position to, say, within one mile. Even so, an efficient black-out may prevent an object within this circle being identified.

But, asks the Commander, would it be any easier for this to be done if a controlled illumination were substituted for the black-out "so that all parts of the circle were equally illuminated by pin-points of light?" May it not be that we have acted in accordance with the primitive man's instinct that "in the dark no one can see me"?

The expert might perhaps object that, whilst it is relatively easy to produce a black-out over the United Kingdom, it is impracticable to illuminate it uniformly, or even to create uniform brightness throughout a given urban area. The most that we have so far been able to do is to achieve uniform illumination in the streets, in which the housetops do not share. If the artificial illumination in the streets were unduly increased their outlines would stand out by contrast. It is true that moonlight, and, on occasion, the reflected light from searchlights, falls on street and housetops alike and, therefore, does something to smooth out inequalities in brightness. If we could count with certainty on this additional illumination during raids we might be prepared to raise the level of brightness in streets to some extent.

Provided it can be shown that the black-out does not make it easier or any harder for a plane to locate its position, there are numerous advantages to be gained by the alleviation of the black-out, which admittedly is depressing, causes accidents, slows up transport, and hampers outdoor work, and provides an excellent background for enemy flares. If there were no black-out it would also be easier to confuse the enemy by the use of light in open spaces.

These are the chief arguments adduced by Commander King-Hall. To these might perhaps be added that freedom from efforts to produce a total black-out might perhaps render it easier to provide light to aid the efforts of our own attacking machines—whose part in night defence seems to be becoming progressively more important.

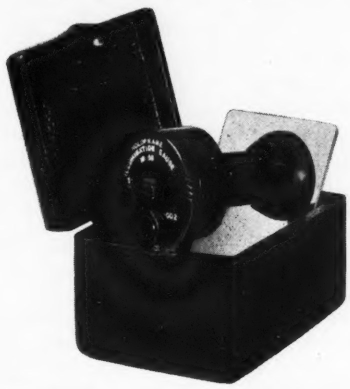
The Recognition of Coloured Light Signals

At the next meeting of the Illuminating Engineering Society in London, to be held at the E.L.M.A. Lighting Service Bureau (2, Savoy-hill, London, W.C.2), at 2.30 p.m. on Tuesday, February 11, a paper on the above subject is to be read by Mr. J. G. Holmes. The paper will describe special apparatus for use in experiments on this topic, and will summarise the results of some 40,000 observations leading to the determination of limits within which signal colours should lie.

Holophane Gauge for Very Low Illuminations

This compact little instrument enables very low illuminations (or corresponding brightness values) such as those met with in A.R.P. work to be checked. It complies with the British Standard Specification for gauges of this kind (BS/ARP 30).

It utilises a telescope 1⅜ in. diam. and 3¼ in. long, a lens with 7 mm. aperture, and an eye-piece through which is seen a white diffusing disc with a small central circular aperture. The disc receives weak illumination from an annulus of radium luminous compound and a greenish filter is interposed in order to obtain a colour match. In order to check illumination values one looks through the aperture in the



A view of the Holophane Gauge for Low Illuminations, showing the telescopic testing device, the test plate and box in which the instruments are housed.

illuminated disc at the detachable white testplate in the customary manner. In testing brightness (in equivalent foot-candles) one looks direct at the surface examined. Two neutral filters, reducing the light under test to 1-10th and 1-100th respectively, are provided. Either disc can be easily brought into position. Two types of instrument intended for measurement of (a) 0.2, 0.02, and 0.002 foot-candles, or (b) 0.1, 0.01, and 0.001 foot-candles, are available.

With this instrument low values of this order can be readily checked. As is usual with a gauge, only one decision is called for—whether the centre of the disc is brighter or darker than the surround—and this can be done by anyone without undue difficulty provided a reasonable time in dark surroundings is allowed for the eye to become properly dark-adapted.

The Economics of Lamp Replacement

Amongst the papers recently read before the I.E.S. local centre in Manchester, to which we hope to refer more fully shortly, was one by the honorary secretary, Mr. Alan H. Owen, which raises a number of interesting points. What in practice should determine when a lamp is to be thrown away? Theoretical curves prepared by experts, showing the ideal "smashing point," by no means always apply. Mr. Owen contrasts the case of a church, using lamps intermittently and paying a high rate for current, with that of a colliery burning lamps for twenty-four hours each day, and with energy at ½d. per unit. There is also the cases of buildings with many long corridors, railway systems, and rural street lighting where the labour of replacing lamps is in itself an item. Finally, there is the all-pervading fact that we are at war. Abnormal conditions may ultimately result in many accepted principles being thrown overboard.

Contrast in Illuminating Engineering

Summary of the proceedings at the Meeting of the Illuminating Engineering Society, held at the E.L.M.A. Lighting Service Bureau, at 2.30 p.m. on Tuesday, December 10th.

In our last issue we made a brief reference to the discussion on the above subject which took place at the meeting of the Illuminating Engineering Society on December 10. Mr. J. M. Waldram, Dr. R. G. Hopkinson, and Mr. W. R. Stevens had made themselves responsible for the opening demonstrations. Dr. Hopkinson was unable to attend, but his place was taken by Dr. Harper. As explained in our last issue, the mode of sharing the discourse adopted by the three authors was somewhat unusual but very effective. Each speaker took up the tale at intervals, and Mr. Waldram, who opened the discourse, also finished up.

Nature of "Seeing."

In his opening remarks Mr. Waldram pointed out that "seeing" involves very much more than the perception of light. It is affected by the combined effects of light, darkness, and colour. Recognition may depend upon a number of factors such as the amount of contrast and colour, the nature and shape of the boundaries, and the familiarity with the scene. Mental association also plays a part in recognition. In illustration of these facts several amusing experiments were conducted. It was shown, for example, how, by a few lines and dashes, the familiar face of one highly respected member of the Society could be suggested, how a lantern slide, apparently consisting only of a medley of colours when the light was weak, became revealed as a basket of fruit when the light was turned full on.

Range of Brightness.

Turning next to the use of "contrast" the lecturer emphasised that, if correctly understood, this term denoted a sensation. It could not itself be measured, though it was possible to prepare numerical statements based on factors responsible for contrast, such as variations in the brightness of objects. Attention was drawn to the enormous range of brightness—varying from the effect of a white surface receiving full sunlight (10,000 ft.c.) down to moonlight and starlight (0.0002 ft.c.), and even lower orders of illumination. The eye could not possibly take in this range simultaneously, the most that it could achieve was about 1,000 to 1. Therefore it had to confine itself to taking in different sections of the full brightness range at one and the same time—in so doing operating in somewhat the same manner as an electrical instrument, provided with "shunts" to multiply the scale readings. The effect of the order of brightness on sensation was admirably illustrated by a lantern slide of an artificially lighted street. Many objects clearly visible when the brightness was similar to that found in a normally lighted street became indistinguishable when the light passing through the slide was dimmed, so that conditions resembling more closely those prevailing in war time were reproduced.

Contrast in Photography.

The importance of these considerations in connection with photography was well illustrated both by Mr. Waldram and Dr. Harper. Experience with a lantern slide showing a pleasing cottage scene was similar to that recorded with the view of the street. With full brightness, corresponding to daylight, there was a wealth of detail. As the brightness was dimmed detail was lost until finally only prominent white objects, such as a wall in the foreground, remained. The same applied to a photograph, illuminated from the front, though in this case the possible range (not exceeding 100 : 1) is considerably less. An illuminated picture of Durham Cathedral served well to show how foliage of trees and other detail is lost as the illumination is diminished. The importance of "photographic contrast," i.e., the measure of the emphasis put upon naturally occurring contrasts in the original, was stressed, and the effects of differing treatment and varying photographic papers were illustrated. It was explained that, when viewing a "standard representation photograph," the sensations of contrast should be as nearly as possible those experienced when viewing the original scene.

Brightness in Relation to Contrast.

Later Mr. Waldram discussed in some detail the intricacy of the factors influencing visibility and the attempts made to devise instruments intended to measure this factor, illustrating his remarks by demonstrating the effect of a "veiling brightness" and the operation of the Lummer Brodhun contrast photometer at low orders of illumination. He recalled the development of formulae embodying "brightness ratio" (B_1/B_2), brightness difference ($B_1—B_2$), and a still more complex expression ($B_2—B_1/B_2$)—all of which went some way towards expressing the conditions determining contrast but broke down when applied outside a limited range. It was repeated that contrast could not be directly measured. Its value could, however, be assessed to some degree by the aid of a full statement of the conditions of brightness and the application of sensation curves.

Some Practical Applications.

In the concluding stages of the demonstration Mr. W. R. Stevens referred to war-time street lighting as an example of the extreme value of the judicious use of contrast and the importance of avoidance of "dazzle" at very low illuminations. He referred to camouflage problems which (i) make objects unrecognisable, (ii.) render them less evident, or (iii.) cause an object to resemble something entirely different. Several lantern slides illustrating the "protective camouflage" adopted by wild creatures amongst snowfields or in the jungle were shown.

Numerous examples of the value of contrast in everyday actions and in industrial operations were mentioned (such as interviewing people with one's back to the window, taking stockings "to the light," reading micrometer gauges, etc.). A final interesting point was the comparison of effects of pictures obtained from pigments (with a very limited range of reflecting power) and from fluorescent materials glowing in the dark and giving power of intensifying contrast and emphasising certain parts of the picture.

Mr. Waldram concluded by emphasising the subtlety and amazing complexity of processes of vision.

Discussion.

In the course of the discussion various speakers drew upon their own experience in order to illustrate the importance of contrast in practice. Dr. W. D. Wright mentioned several optical illusions experienced when motoring which had proved very disconcerting—such as a cart-wheel track, masquerading as the central white line, which appeared to veer suddenly to the right. Mr. Appleby discussed the combination of spot lights (of which ninety-five were recently used in one American theatre) in conjunction with make-up on the stage, and Mr. Dow referred to the curiously vivid spectral brightness of white objects seen at close quarters in dense darkness. Dr. Walsh recalled the limitations of painters in getting effects by the mixture of solid pigments and the possibly greater effectiveness of transparencies.

Vision in Very Weak Light

In what follows we give a summary of the proceedings at the meeting of the Illuminating Engineering Society held on January 14th, 1941.

This meeting was devoted primarily to a paper on "The Fundamental Principles of Vision in Very Weak Light," presented by Dr. W. D. Wright. In the course of the proceedings a few words were said by Mr. J. S. Dow on the substance of the Report on War-time Street Lighting, formally presented by Mr. Percy Good at the previous meeting, and some demonstrations, illustrating certain of its main principles, were arranged. Both items were discussed jointly afterwards.

In introducing his subject Dr. Wright recalled that the "apparent" or "subjective" brightness of a surface depended on the amount of light emitted by the surface and the sensitivity of the eye under the prevailing conditions. Sensitivity is often specified in terms of the threshold brightness, but is sometimes better represented in terms of apparent brightness. The author therefore suggested the preparation of a scale of apparent brightness, based on a new unit, "the brill," to be defined as follows:—

When an extended surface of physical brightness B is viewed by a dark adapted observer using both his eyes, then the apparent or subjective brightness A should be calculated from the equation:—

$$A = 10 \log_{10} (B + 1).$$

The unit of apparent brightness may be called a "brill" and A will be expressed in brills when the unit of B is 10^{-3} e.f.c.

Dr. Wright presented a table comparing values of physical brightness from 0.00001 to 100 e.f.c. with corresponding values of apparent brightness, ranging from 0.04 to 50 "brills" for a dark-adapted observer. Scales for other adaptation levels could also be prepared.

Experiments were next described illustrating the process of dark adaptation. After ten minutes the eye had become fully sensitive to light but required fifteen minutes to become fully sensitive to the absence of light. A study of the phenomena of dark adaptation shows the great advantages to be derived from even a small amount of light; for example, in diminishing the time of adaptation and producing a more stable state of the eye.

Interesting information on the relation between area of object and apparent brightness, at low illuminations, was given. It was mentioned, for instance, that the value dropped in one case from 1.1 to 0.5 brills when the angular subtense of the surface was reduced from 4° to 1°.

The scale of subjective brightness is also helpful in enabling effects of glare and contrast to be studied. It may be inferred that for a person under black-out illuminations the maximum permissible contrast should be 20 brills, corresponding to subjective brightness about 0.1 e.f.c. Diminution in area, by reducing apparent brightness, also reduces the available contrast.

Dr. Wright also demonstrated a simple device for the testing of cases of defective night vision—a condition obviously dangerous in the case of those operating in the black-out. Preliminary tests on nearly 300 persons indicate that about 5 per cent. require about four times the light needed by a normal person.

In conclusion, Dr. Wright described an apparatus, the "brill-meter," for the purpose of testing subjective brightness, based on the comparison of impressions received by one dark adapted eye and the other eye exposed to the conditions which it is desired to study. The instrument had been found to give quite useful results at low orders of illumination, although, naturally, an accuracy of the same order as that attained in ordinary photometry cannot be expected.

At the conclusion of Dr. Wright's address, a brief summary of the Report on War-time Street Lighting (see "Light and Lighting," December, 1940, pp. 196, 198) was given by Mr. J. S. Dow, who pointed out that Dr. Wright's work had a direct bearing on many points emphasised in the report, e.g., the value of even the very low illumination provided for war-time street lighting in promoting a certain degree of "stability." Dr. Wright had also confirmed the influence of area of object on apparent brightness and the approximate estimate of the limit of brightness of objects in the street, as set out in the report.

Mr. Dow then showed a series of demonstrations, kindly arranged by Mr. Sawyer and his staff at the Bureau. There were, for example, a series of discs of diminishing diameter, white on one side and dark grey on the other, and cardboard figures of people wearing clothes of different colour and reflecting power, all seen against a grey-brown background of reflecting power resembling that of the average street pavement. After inspection at relatively high illuminations of from 1 to about 30 ft.c., the illumination was reduced by stages to 0.2, 0.02, 0.002, and finally 0.0002 ft.c.—the latter value being furnished by an actual war-time street lighting unit under conditions resembling those in the street. It was shown how the circles of smallest diameter appeared brighter than the larger ones and tended to become invisible to direct view when the illumination was reduced to the lowest value, though at normal illuminations all appeared equally bright. The effect was accentuated when the series of grey discs was substituted for the white ones.

Useful lessons were drawn from the appearance of figures of people, one point of special interest being the greater distinctiveness of persons in light clothing under war-time street lighting, though the contrast with the background, at high illuminations, of the figures in dark clothing seemed equally great at normal illuminations. It was also shown how, with 0.0002 ft.c., a sign having a brightness of 0.02 e.f.c. produced no appreciable glare, whereas one of about 1.5 e.f.c. (approximately the value named for white "crosses" in the Lighting Order) did interfere with vision appreciably, and one of 30 e.f.c. (occasionally met with in streets) quite obliterated the outlines of figures. At somewhat higher illuminations, however, visibility improved substantially and effects of glare became less, showing the justice of the contention in the report that higher local illuminations might sometimes be furnished with advantage.

Good Lighting and Industrial Welfare

A report on the Supply Services, recently presented by the House of Commons Select Committee on National Expenditure and summarised in "The Times," contains a special reference to the value of good illumination in industry.

"The interior lighting of factories and workshops," it is remarked, "should be the subject of full and urgent investigation, as eyestrain is one of the major causes of industrial fatigue."

The importance of improvement in lighting conditions, which removes disabilities limiting the workers' efforts, lies in the fact that we have here a possible method of improving output without a corresponding increased tax on endurance.

I.E.S. Code of Recommended Values of Illumination

Notes on a lecture delivered by Mr. H. C. Weston to Industrial Medical Officers at the London School of Hygiene and Tropical Medicine on Wednesday, November 22, 1940.

In introducing his subject, Mr. Weston pointed out that some knowledge of the bases of good lighting practice is of value to the industrial medical officer, who needs to be able to assess the probable significance of conditions of lighting in his own factory in relation to "sickness" and accident incidence, and to general well-being. Without assuming the functions of the illuminating engineer, he should often be able to give advice that will help to secure physiologically and psychologically satisfactory lighting.

The provision of sufficient and suitable lighting is now a legal obligation laid upon every factory occupier, and certain minimum standards of lighting have been prescribed in regulations made by the Minister of Labour. Better lighting—in conformity with the I.E.S. code—is now being insisted upon in vital factories under the control of the several Ministries concerned with war supplies.

Three fundamental and interrelated factors are involved in seeing (i) light, (ii) the objects to be seen, (iii) the human organs of sight and the central sensory equipment with which they are linked. All are variable and, within different limits, controllable.

The author proceeded to explain and illustrate some of the results of research dealing with the interrelation of these factors. He gave an outline of the scientific basis underlying modern recommended lighting practice. In particular, the relation of response (visual performance) to the logarithm of stimulus (brightness or illumination) was stressed as of fundamental importance in lighting practice.

Mr. Weston's analysis of the I.E.S. "Code" Of Recommended Values of Illumination is of special interest, and in what follows we give a summary of his remarks. He pointed out that the code is logarithmic, in that the means of its successive ranges of illumination roughly correspond with successive divisions on a scale of equal ratios. The seven categories into which visual tasks are divided are necessarily broadly defined, but the "average task" of each may be considered as differing from the next in the series by approximately an equal amount of difficulty. The code is diagrammatically represented in Fig. 1.

By a re-classification of tasks, a strictly logarithmic code can be formulated, such as that represented in Fig. 2, which covers the same total range of illumination values. In this, six categories of task are distinguished, for each of which a definite illumination value is prescribed. The lowest of these values—3 ft.c.—is determined, as it should be, largely on psychological grounds, and successive doubling gives the values for succeeding categories. These are optimum values for the "average task" in each category. They are not critical, a deviation of one tenth up or down having a very small effect. But the categories are broad, and, though attention is focused on the mean values, the necessary ranges of values to cover tasks of more or less than average difficulty are obtained by a plus and minus "tolerance" of one third of the mean value for each category. Thus, to construct the code it is necessary only to remember the lowest value, the range-fixing fraction, and the principle of doubling. From the fundamental relation on which it is based, it might be termed the "vision v. illumination code." To keep this relation in mind, the category definitions used in Fig. 2 are so arranged that their initial letters form the word "vision."

Besides showing the effect of illumination on the performance of the average worker, its effect on individual differences of performance was illustrated by means of diagrams representing the mean variation of individual performances from the average at different levels of illumination. These diagrams are reproduced in Figs. 3 and 4.

Fig. 3 refers to the performance of "fine" work and shows that, while the average performance increases with illumination, individual performances show an increasing trend towards uniformity, i.e., the higher the illumination the less they deviate from the average. This is due to the relatively greater effect of increasing illumination on the performance of sub-average individuals, so that they tend more and more to catch up in efficiency with those individuals in the group whose light need is less. In very fine work, the illuminations required by different individuals to achieve the same performance (whether absolute or relative to their individual

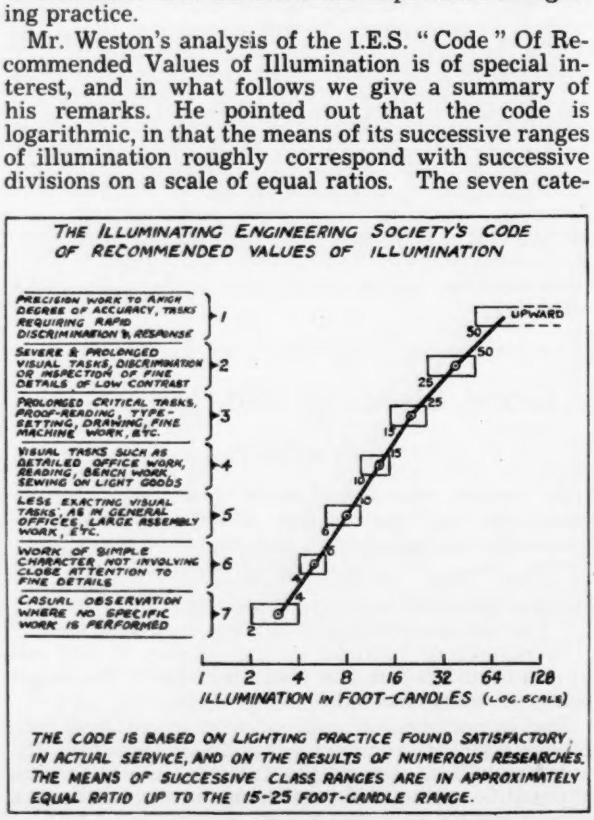


Fig. 1.

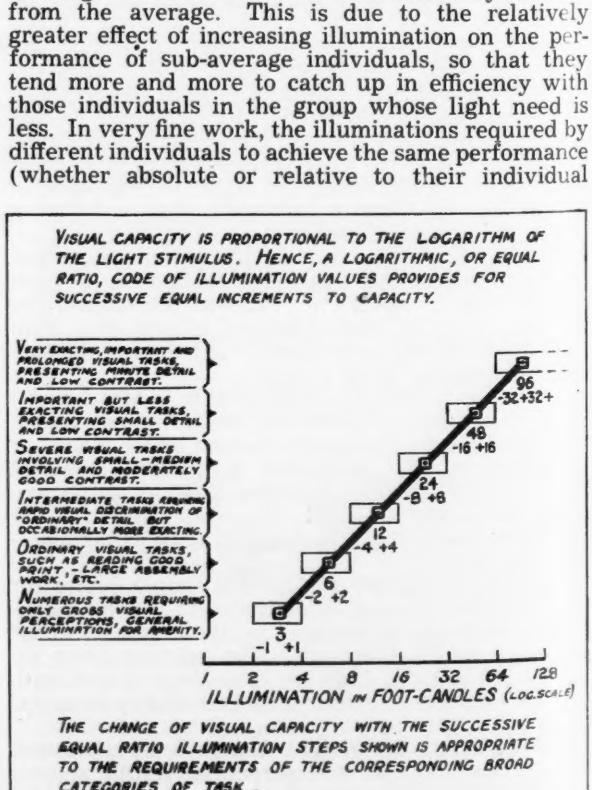


Fig. 2.

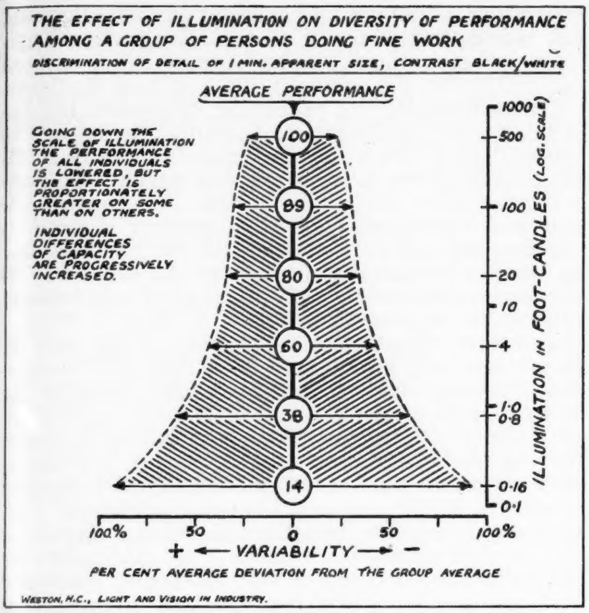


Fig. 3.

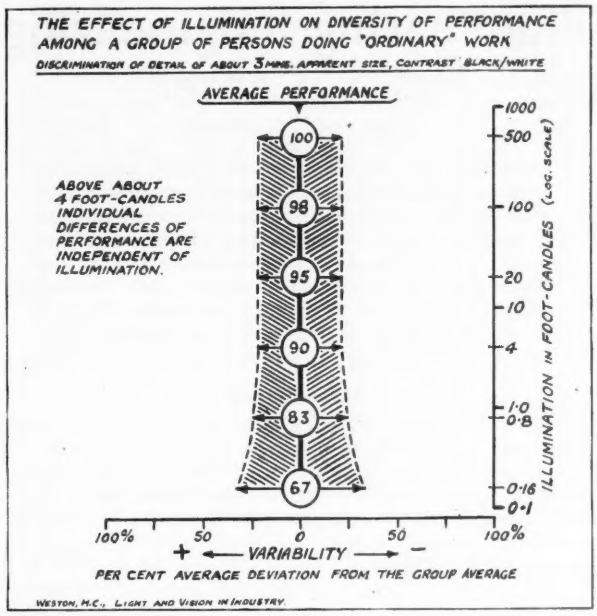


Fig. 4.

maxima) may differ so widely that the optimum for work of this category must be decided individually. Hence the need for supplementary local lighting units which the worker can position to give him the illumination which meets his individual need.

The importance of suitably bright surroundings, from the standpoint of visual efficiency, was dealt with, and it was pointed out that good general lighting has a tonic effect, necessary for every worker irrespective of the demands the work makes on his visual capacity. The concluding portion of the lecture was devoted to consideration of the causes of eyestrain, the importance of thorough ophthalmological examination of persons continuously engaged on fine work, and the use of optical aids to vision when lighting, however good, cannot make the work entirely innocuous to the worker

Industrial Light Conditioning

There has been a general tendency recently to emphasise the importance of the quality of industrial lighting—a complex factor depending not only on satisfying certain physical conditions not always easy to secure, but also on the interpretation of the workers' outlook, often partly determined by mental associations.

The use of the new fluorescent tubular lamps, more especially when installed in "artificial skylights" of brightness naturally excites interest. The high efficiency, low brightness, and approach to daylight-effect of such lamps are substantial advantages.

We reproduce herewith two illustrations showing the application of these lamps in trough reflectors and artificial skylights respectively. Attention may be drawn to the very soft shadows and the apparent ease with which objects are revealed—a great advantage of this form of lighting.

Fig. 1. A development workshop in which special lighting from Mazda 80 watt tubular fluorescent lamps in trough reflectors is provided.

Fig. 2. An assembly shop provided with lighting by 80 watt tubular fluorescent lamps fitted into artificial skylights of large area and low brightness.

In sending us these pictures the British Thomson-Houston Company, Ltd., present the following "code," as an attempt to express the measures needful in order to obtain high quality industrial light conditioning:—

(1) Regard the problem from the workers' point of view rather than that of the casual observer.
(2) Eliminate glitter from the work and glitter and dazzle from the local field of view.
(3) Provide adequate illumination.
(4) Eliminate dazzle from the general surroundings.
(5) Provide reasonable brightness of walls, ceilings, or other surroundings.
(6) Take into account the purely psychological factors by promoting cheerful, comfortable, and safe working conditions.
(7) Employ full engineering and designing skill to keep installation and maintenance costs at lowest level consistent with the best lighting results.

Illuminating Engineering as a Career

by J. B. HARRIS

(Although the development of a new profession presents difficulties at the present moment, it is well to look to the future and to review after-war possibilities. In what follows we present the views of one of the younger I.E.S. members on "Illuminating Engineering as a Career." Whilst some of the suggestions may be regarded as debatable, there is much with which members of the Society as a whole will doubtless be in cordial agreement.—*Ed.*)

Introduction

Since the beginning of evolution the work of man has been made easier by the application of natural forces and materials to suit a particular task. As far back as the Stone Age there were engineers who fashioned flints to form weapons and tools and who utilised trees to construct boats. Throughout the world in the different eras engineers have helped to build and to preserve empire and generally assist in the progress of civilisation. The Greeks, the Egyptians, the Romans, and the Chinese successfully carried out the construction of canals, artesian wells, aqueducts, dykes, and dams, and also introduced irrigation schemes. In these days, engineers relied upon the strength of man for their source of power, and engineering was undivided into specialised branches. Throughout the years, scientific workers, helped greatly by the writings of early engineers, have gradually widened their knowledge. In the 15th century, Leonardo da Vinci, who was the founder of mechanical science and worked as a consulting engineer, architect, and sculptor, wrote a treatise dealing with navigation, military engineering, hydraulics, architecture and general technology.

Recent progress has been so rapid that engineering has greatly widened in character, and this has necessitated a more complete study of its sub-sections. Whereas at the beginning of this century the division of engineering into three main branches (civil, mechanical, and electrical) was considered sufficient, subsequent concentrated research and investigation have resulted in a great number of specialised sub-branches, each of which may to-day be considered a complete subject for study. Fig. 1, though not necessarily complete, gives some indication of the above-mentioned growth.

Illuminating Engineering as a Profession

Perhaps the newest of engineering professions is that dealing with "Illumination," and, apart from its undoubted importance in modern civilisation, it has an interesting appeal in view of its relationship with numerous other subjects as widely divergent as Physics, Architecture, and Physiology. Much might be written on the use and abuse of artificial lighting, but thanks to the efforts of the Illuminating Engineering Society the public are beginning to give more recognition to the work of the Lighting Engineer. Of importance during peacetime, this work has become, during hostilities, an essential factor in the prosecution of the war. The investigations of lighting men in recent months, many of which were commenced at the instigation of the Government, are now well known and need no reiteration. Illuminating Engineering may now be said to have become an established subject of study in the same way as the other main branches of engineering, and it should always be considered as such.

The term "Illuminating Engineer" is not easy to define, but very briefly may be understood to represent a person who is thoroughly conversant with the theory and practice of illuminants and illumination. In order to encourage students to pursue a course dealing with the subject of illumination, it is necessary to ensure that on completion of their training there will be the required industrial openings. Persons possessing the specialised knowledge should be able to find employment in any of the following capacities, and it is hoped that the bodies concerned will sufficiently realise the necessity of employing them.

1. *Illuminating Engineering Department of Firm of Lamp and/or Fittings Manufacturers.*

This is perhaps the section of the industry offering the largest scope, and the work is very interesting, especially if of a general kind including the planning of lighting schemes for all types of buildings and the design of lighting fittings. The variety of inquiries which enter the department tend to arouse an enthusiasm in the engineer, which cannot be equalled by an occupation in which the work is monotonous and unchanged in type. No doubt much of the work will entail visits to sites and meetings with clients and professional men, and the student should acquire a pleasing personality and possess a concise knowledge of expression.

2. *Government Department.*

The increasing amount of work undertaken by the various Ministries has resulted in the employment of personnel having a specific knowledge of lighting matters, and it is hoped that this policy will continue, instead of the popular idea of employing engineers whose knowledge is of a wider character. Various committees are set up from time to time, at the request of Government Departments, to study specific problems such as Factory Lighting, Street Lighting, etc., and many of the members of these are on the staffs of the various Ministries, thus further emphasising the need of employing engineers having a specialised lighting knowledge.

3. *Engineering Department of Municipality.*

Various City Councils consider Street Lighting and allied matters of sufficient importance to warrant the

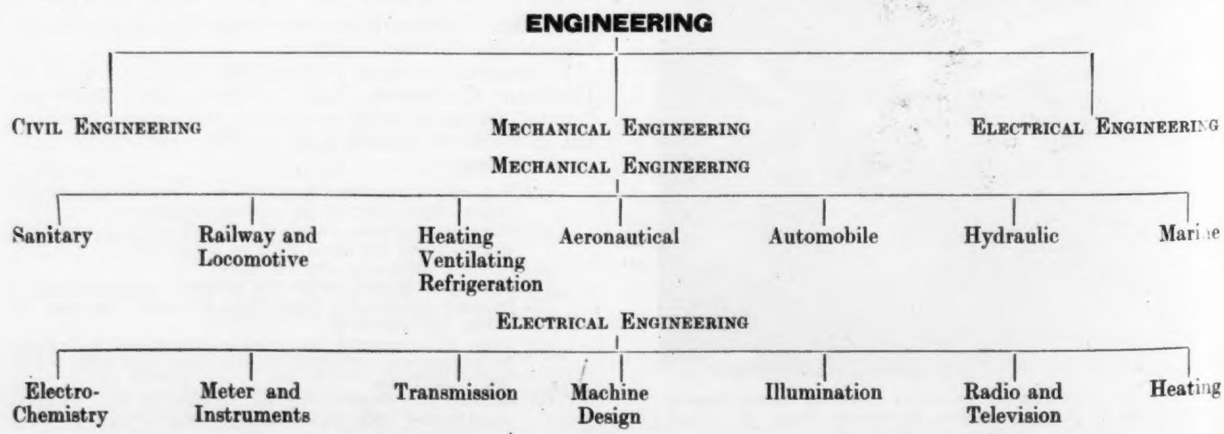


Fig. 1

employment of a City Lighting Engineer or Inspector. The work necessitates an unbiased knowledge regarding the application of gas and electricity, together with good experience in the testing of lighting fittings and the transmission of both these types of energy. The services of Lighting Engineers are also required on the staffs of the electrical and gas departments of Borough Councils in connection with the treatment of Hospitals, Town Halls, Libraries, and Schools.

4. *Consulting Electrical Engineer.*

The services of electrical consultants are in constant demand, and the wide variety of problems that arise frequently necessitate solution by specialists. Very often demands arise for the unbiased opinion of an outside authority on illumination, and this indicates the need for a purely professional class of Consulting Illuminating Engineers. An engineer of this type should be capable of giving advice free from commercial bias, offering his services in the same way as an architect and thereby increasing his professional status.

5. *Gas and Electricity Supply Companies.*

The value of a staff of persons known as Consumers' Engineers has long been realised by supply companies, and lighting and other loads have consequently been fully developed. The work of Lighting Engineers, who are specifically employed as such by many concerns, consists of advising generally on illumination problems and also includes giving lectures and demonstrations in showrooms. In this particular branch of the industry a knowledge of publicity is particularly useful. All companies having a large number of consumers should employ specialist technicians, perhaps imitating the American idea of employing staffs of "Lighting Advisers." This method of building the lighting load by means of personal contact between the supply authority and the consumer has been proved a successful venture, and it might be noted that posts of this nature would provide an interesting career for women.

6. *Railway Company.*

The illumination of stations, yards, and buildings associated with railroad transport is carried out by means of gas, electrical, and oil light sources, and companies usually have a special department for dealing with work of this nature. The peace-time lighting methods adopted in many railway stations, especially termini, leave much to be desired, and considerable improvement might be effected benefiting both workers and passengers.

7. *Teaching Profession.*

With the increased number of courses which will eventually be arranged by colleges and technical schools, there will be a demand for Lecturers and Demonstrators, who will have to possess a wide knowledge of Illuminating Engineering and allied subjects. While no doubt evening courses will be undertaken by Visiting Lecturers, day courses will necessitate the employment of full time lecturers, resulting in such occupations forming a definite career for those interested in the academical side.

8. *Research Work.*

Many students have a definite leaning towards research as distinct from commerce. The larger firms have well-equipped laboratories and staffs capable of carrying out this type of work on lighting sources and equipment, and the application of same. Lighting investigations are also undertaken by Government Departments and other associations on problems concerned with industrial welfare, psychology, and health. The work consists of preparing reports dealing with prevalent conditions and suggesting improvements for the benefit of workers.

Education and Training.

Having proved the existence of occupations for qualified Lighting Engineers, the next important question concerns education and training. Certain bodies, notably the Lighting Service Bureau of the E.L.M.A., have held annual short courses dealing with lighting application for many years past, and a special short course was also arranged some time ago at the Regent Polytechnic. Illumination as a subsidiary subject of Electrical Technology receives a brief treatment in a general electrical engineering course. The first complete evening course lasting for a full session was held at the South-East London Technical Institute in 1937, and in the year following this Institute, together with others, held courses preparing students for the City and Guilds Examination in Illuminating Engineering. The syllabus for this examination is quite extensive and very suitable for students gaining practical knowledge during the day. It is hoped, however, that eventually it will be possible to obtain a chair in Illuminating Engineering at a University, which would permit the granting of a B.Sc. degree in this subject. The need for this has arrived, and the following suggestions might serve as the basis for such a course which would occupy the normal three years leading up to the Final Examination.

First Year Course.

The first year of the course should consist of studying the subjects associated with other Engineering degrees, viz., Physics (Heat, Light, Sound, Mechanics and Electricity and Magnetism), Chemistry, Mathematics, and Engineering Drawing. The Intermediate Examination for this degree would be taken at the completion of the year's study, and the knowledge gained would serve as a good basis for the subjects to be studied later. In suggesting the portion of the course to be taken in the subsequent two years, importance has been given to the subjects which are so allied to that of "Illumination" proper. The writer has not entered into details of the syllabus of each subject, but has rather suggested main groups of study.

Second Year Course.

1. *Principles of Illumination.*—This should include laboratory work.

2. *Mathematics.*—This is an essential subject for all engineering studies.

3. *Chemistry and Physics.*—Study of these is specially necessary for students contemplating research work. Laboratory work should be included.

4. *Electrical and Gas Technology.*—These should include laboratory work.

5. *Strength of Materials.*—A knowledge of this subject is required for fittings design work. Experiments should be undertaken in the laboratory.

6. *Modern Language.*—Much investigation is carried out by foreign engineers, and it is very necessary to be capable of reading original texts.

Third Year Course.

1. *Lighting Application.* — This should include laboratory and field work.

2. *Theory and Design of Light Sources and Equipment.*—This should include laboratory work.

3. *Electrical and Gas Technology.*—This should be of a more advanced character than in the previous year and should include a study of Distribution and Control Systems.

4. *Elementary Principles of Architecture.*—A study of this subject is necessary for a proper appreciation of modern lighting application.

5. *Elementary Economics and Business Administration.*—This is particularly useful for students planning a commercial career.

6. *Physiology of the Eye.*—This is essential for the satisfactory study of all lighting problems.

The importance of practical experience cannot be overstressed, and arrangements should be made to enable students to spend a short period (during

second year summer vacation, perhaps) in the works or office of a reputable firm. It would also be necessary for the College authorities to ensure the provision of well-equipped laboratories, in order that the students may be thoroughly conversant with modern practice. Lectures should include demonstrations, and should be illustrated with slides and possibly films. In conjunction with the normal technical training, consisting of lectures, laboratory work, and industrial experience, the following should be arranged:—

(i) Special lectures by eminent Lighting Engineers enabling students to have authoritative information on modern tendencies.

(ii) Visits during the term to well-known examples of good lighting application and to permanent exhibitions of lighting practice, viz., Home Office Industrial Museum, E.L.M.A. Lighting Service Bureau, Science Museum

(iii) Visits to the works and research laboratories of large firms for the purpose of seeing the manufacturing and testing of light sources and equipment.

It will be seen from the above that co-operation is required from the large firms, and this would no doubt be given. Perhaps the best way of facilitating the arrangements would be the formation of a committee composed of the large firms, the teaching profession, and representatives of the Illuminating Engineering Society.

Conclusion.

The Illuminating Engineering Society has taken a very progressive step by initiating a class of membership known as "Fellows," election to which necessitates a recognised standard of education, together with a number of years of practical experience. This in itself will undoubtedly encourage rather than deter the membership roll, as it establishes "status," which the Lighting Engineer has always needed. The writer would like to suggest, however, that more thought be given to the question of changing the name of the Society to "The Society of Illuminating Engineers," with a consequent adjustment of membership classes, whereby persons interested in lighting matters are not precluded from joining but are admitted in a grade similar to that of Companionship Membership of the Institution of Electrical Engineers. Eventually the Society might be able to obtain a Charter enabling qualified men *only* to describe themselves as "Chartered Illuminating Engineers."

It is hoped on returning to normal times in the very near future that the boom that will undoubtedly take place in technical education will enable the requisite importance being given to the training of Lighting Specialists on the lines indicated above.

Artificial Lighting and Eyesight

There are signs that at long last more attention is being paid by lighting experts to the needs of the eye, in addition to the mechanism of lighting. In a recent issue of "Light and Lighting" a plea was made for more consideration of the quality of lighting. Our attention has also been drawn to this point by recent articles of Mr. G. V. Downer ("Aircraft Engineering," September, 1940, and the "Electrician," September 20, 1940), who describes the structure and behaviour of the eye in considerable detail and analyses the effects upon it of modern methods of lighting. Whilst it may be accepted that special tasks may make necessary special lighting devices, there is little doubt that the main elements in the quality of lighting desirable for the great majority of processes are, as Mr. Downer remarks, even distribution, freedom from glare, and elimination of troublesome shadows. The very soft shadows arising from indirect lighting (often but not quite correctly described as "shadowless") are being appreciated to an increasing extent. In many cases, for example in drawing offices, this quality is of outstanding importance. Another defect on which Mr. Downer lays stress is the "uneasiness" of much of the present lighting. This is not exactly the same as the fundamental error of glare from exposed sources of light, but arises whenever patchy effects are produced—as is not infrequently the case when there is much individual lighting of desks or machines.

There is a general belief that defective vision is more widespread to-day than at any previous period in history. There are doubtless many contributing causes, arising out of present economic conditions, the stress and strain of modern life, errors in diet, and prolonged close work by artificial light. Periods of rest, during which the eye is relieved by focusing on more distant objects, are helpful in giving relief. But it is natural to suppose that unsatisfactory methods of artificial lighting—especially during periods of intensified effort such are we are now experiencing—accentuate the tendency.

The essence of the matter is that we should learn to think in terms of the needs of the eye and the quality of the light furnished, as well as the actual value of illumination in foot-candles which is provided.

A Portable Standard of Brightness

A very useful addition to the series of British Standard Specifications dealing with A.R.P. lighting is BS/ARP 52, which describes a simple portable standard of brightness. A previously issued specification, BS/ARP 30, dealt with gauges for the measurement of very low orders of illumination. These had the merit of simplicity as compared with illumination photometers in that they afford a "stop-go" operation. The user has only to make one test, to apply the gauge and decide whether the centre of the photometric field is or is not brighter than the surround.

But, nevertheless, for certain operations an apparatus of this type, utilising a telescope, presents difficulties in inexpert hands, and something even simpler is needed.

This need has been met by the brightness standard now prepared, which seems well devised for such purposes as determining whether A.R.P. signs or signs in shop windows exceed the permissible limits (0.04-0.1 and 0.02 e.f.c. respectively).

The instrument consists essentially of a translucent white screen forming one side of a box and illuminated by an electric lamp housed in the box. The brightness of the screen is controlled by a rheostat provided with a scale by means of which the required settings of brightness can be made either direct or by reference to a table. Provision is made for coloured translucent screens to be superimposed on or substituted for the white screen, to enable the apparent brightness of coloured surfaces to be checked. The lamp is to be fed by a non-spillable accumulator or dry cell of ample capacity.

A specimen apparatus of this kind, of robust construction, is illustrated in an appendix to the specification. Three patterned grids, hinged to three sides of the frame fixing the glass screen to the box, which carry sheets of translucent material, one white, one red, and one blue, are furnished.

The instrument is adapted to the testing of the following brightness values: 0.02, 0.04, 0.1, and 0.5 equivalent foot-candle.

It is emphasised that the brightness mentioned in the specification is the "apparent brightness" and not the brightness measured on a photopic scale—a question which is fully explained in another appendix, and is of importance in testing coloured objects.

THESE ACCIDENT FIGURES MUST BE CUT

The Ministry of Labour states that accidents have, since the black-out, increased by 42%. Inadequate and unsuitable lighting is one of the chief causes and, throughout the Country, poor lighting in factories is still much in evidence.

BTH LIGHT-CONDITIONING will reduce accidents

What was considered good lighting in pre-war days is inadequate and dangerous now that the whole working day is spent under artificial lighting instead of only an hour or so.

BTH Light-Conditioning reduces accidents and, by lessening eyestrain and mental and physical fatigue, ensures more accurate workmanship. Make use of the services of BTH Lighting Engineers. You will be under no obligation.

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Some Lighting Problems in Corrosive Atmospheres

In what follows we give a summary of a paper recently read before the North Western I.E.S. Local Centre by Mr. J. Bolt

This short paper is intended to deal with the subject on broad lines, consideration being given to the problems arising in the illumination of interiors where the atmosphere is laden with chemical substances or otherwise corrosive with chemically laden and similar atmospheres, and to the materials at present available for combating such conditions.

The difficulties and problems met with in connection with the lighting in such situations are, in most cases, not so much *lighting problems* in the ordinary sense of the word as problems of condition and maintenance. It is necessary to ensure that the installation will be reasonably durable at the same time making certain that the operatives shall have sufficient illumination for the carrying out of their work in an efficient manner.

The surrounding atmosphere may in practice contain acids or alkalis in the form of spray. In some cases this may also be associated with a fairly high ambient temperature. Two typical instances may be cited:—

(1) The lighting of brine evaporating pans in salt works.

(2) The lighting of a plant producing caustic soda.

In the second case the atmosphere is so bad that any form of fixed lighting is impossible, and one has to resort to portable equipment. Even when this is done, and non-metallic gear is used exclusively, the life of material is extremely short, and the results obtained may be far from satisfactory.

Variety of Problems.

At the outset it must be realised that every job needs special consideration, dependent upon the type of work and processes to be carried out in the building under consideration. Thus, in connection with the rayon industry, it is possible to design a lighting installation on quite orthodox lines, provided that special care is taken with the sealing off of the cable ends, where they terminate in the lampholders, ceiling roses, etc. Special precautions should be taken to see that all metallic parts, etc., such as lamp caps, are effectively shielded from the atmosphere. Mr. Bolt described forms of equipment designed by him for use. The fittings were wired with C.T.S. cable, which should preferably be run on cleats, so as to secure the maximum amount of ventilation around the cables. Care should be taken in the fixing of both cleats and fittings, so that the possibility of moisture collecting, due to condensation around the cables, is reduced to an absolute minimum.

The reflectors for an installation of this kind can be of the standard type, but the vitreous enamel is not beyond suspicion, and one should guard against (1) failure to enamel successfully the edges of the fitting, and (2) liability of moisture to collect inside the beaded edge. Otherwise the metal in the reflector will be attacked and its useful life considerably reduced.

Limited Choice of Reflectors.

This type of installation is reasonably good where conditions are not too severe, but it would be quite inadequate in, say, an accumulator plate-forming shop, where the atmosphere contains a considerable amount of free sulphuric acid in the form of spray, or, again, over brine evaporating pans, referred to earlier. In both these situations the atmosphere is highly corrosive, and the only type of lighting installation that could be applied to them would be porcelain acid-proof fittings (more usually referred to as dyeworks fittings), completely enclosing the lamp; or, alternatively, by means of drop pendants, where the lampholder, ceiling rose, etc., are fitted with some type of effective sealing chamber to protect the cable ends and terminals, and are also designed to cover the lamp cap. In both these types of installation wiring to the points should be in C.T.S. on cleats as previously described.

From an illuminating engineering standpoint such methods must be considered very crude, owing to the very limited choice of fittings available. Even if lighting points are located to the best advantage for the work in hand the results are apt to be poor and the values of illumination specified in the " Fifth Report " may be nowhere approached.

It would appear that there is an excellent opportunity for fittings manufacturers to examine the possibility of making a reflector that will stand up to a corrosive atmosphere of orthodox design, in non-metallic material, and having good reflecting properties. Experience with various plastic materials in such atmospheres suggests that they might offer a solution to the problem. For instance, the acrylic range has a sufficiently high resistance to temperature, and decomposition does not begin until about 365° F. This material has also a very low-water absorption and resists acids and alkalis and many other chemicals.

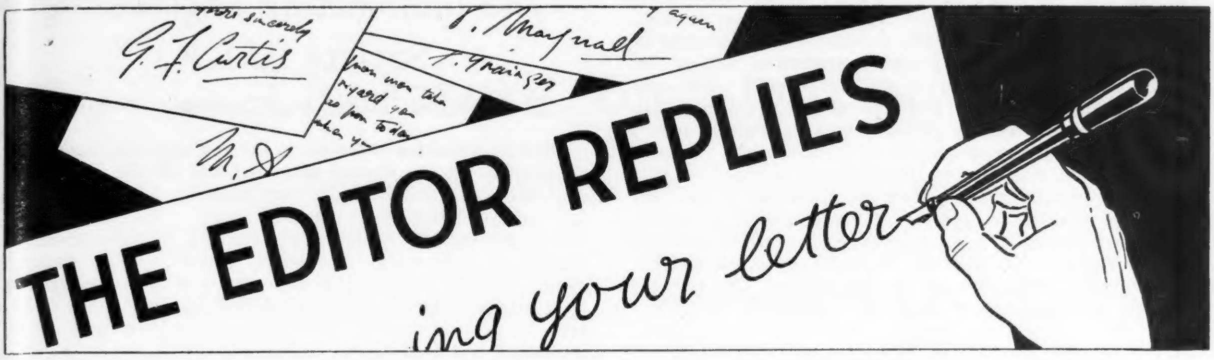
Plastic Materials.

Commenting further on the qualities of plastic fittings, Mr. Bolt stated that, for severe situations those with bituminous binders offered the best results. They had good acid-resisting properties, and reasonable mechanical strength obtained by fibrous reinforcement and thick-walled design. This is a thermoplastic material, but the softening point is sufficiently high for most purposes.

Thermosetting compositions of the phenol-formaldehyde and cresol-formaldehyde type have been used with success in relatively bad situations. This range, of course, embraces materials sold under numerous trade names. The urea-formaldehyde group, etc., are also useful in view of their non-tracking properties. Particular attention should, however, be paid to the filler used in the production of such moulding; only sufficient should be used to give reasonable strength and good working properties—otherwise trouble will be experienced through distortion, etc.

This whole question of the choice of material for fittings and lighting equipment is a very wide one and can only be briefly touched upon in the limited scope of this paper. It would not be complete, however, without some reference being made to porcelain. This, of course, stands up well in the most severe conditions. Its chief drawback, as compared with the various plastic materials, is that it cannot be moulded to such fine limits and is not so robust. There is also the possibility of corrosive liquid creeping around threads, etc., and eventually attacking the metal part inside the fitting.

The short survey given in this paper is an attempt to visualise some of the problems met with when one is called upon to give advice on the illumination of interiors when unusual conditions are encountered, and it is hoped that the observations made will be of some guidance to members when they encounter similar problems.



My attention has been drawn to one or two apparent discrepancies in the **I.E.S. "Recommended Values of Illumination."** It has been pointed out that engraving is stated in the classified processes (p. 8) to need over 50 ft.c. Yet in the initial broad classification (p. 5) this process appears in Class 2 (25-50 ft.c.). Similarly, typesetting, which, on p. 10, is credited with 25-50 ft.c., appears on p. 5, in Class 3 (15-25 ft.c.). According to my recollection, the higher values in the classified list, which were modified when the pamphlet was last revised, are correct, and the inclusion of these tasks in the classes mentioned in the initial ranges is an oversight—which will doubtless be eliminated in the next revision.

Another point, raised by Mr. Howard Long, is that the Fifth Report on industrial illumination and the subsequent Regulations do not recognise a **lower working illumination than 6 ft.c.** (with certain defined exceptions). Yet in an appendix readers are referred to the I.E.S. "Recommended Values," in which two lower classes 2-4 and 4-6 ft.c. are tabulated. My impression is that the reference in the Fifth Report is directed primarily to the classified processes, in which very few operations requiring less than 6 ft.c., are mentioned. It must also be borne in mind that the Fifth Report, which goes much further than the Fourth Report (issued only about two years previously), relates to *war-time industrial lighting*. Under *normal conditions* it should, one would think, be recognised that there are many simple processes for which a standard of less than 6 ft.c. would suffice.

In view of my remarks on the **use of torches during air raids** in our last issue (Nov., 1940, p. 189) it is satisfactory to note that some concession has been made. Torches are allowed provided the aperture is not more than 1 in. in diameter and the light is dimmed with a piece of newspaper or its equivalent. The most important consideration, however, is still the way in which the torch is used. Few torches are likely to be objectionable if consistently pointed downwards, whilst even a feeble brightness may be visible from a great distance if the beam is allowed to travel above the horizontal.

My remarks on the **screening of side lamps of vehicles** have drawn a protest. It is urged that users of the road at night already find sufficient difficulty in distinguishing the outline of passing vehicles. Conditions would become impossible if all light emerging horizontally were cut off. This is quite a fair comment. My suggestion, however, related chiefly to the screening of light directed *upwards* from side lamps, which is of no material value to drivers or pedestrians, but may render the lights perceptible by hostile aircraft. Some light escaping sideways might well be allowed, but even here some degree of screening is desirable, and the needs of traffic would be met by a much lower order of brightness. People still fail to appreciate the effect of exposed lights on vehicles in the dense darkness that now prevails. A comparatively bright light escaping sideways merely dazzles the other users of the streets, making it more difficult than ever to distinguish outlines. What would be much more desirable, from this standpoint, would be the application to the sides of vehicles of very subdued light from well-screened sources—illuminating as large an area of the vehicle as possible, but to a degree of brightness only comparable with that furnished by war-time street lighting.

The need for better **lighting amenities in Anderson shelters** and the like has been urged recently. There are several B.S.I. Specifications dealing with public shelters. Is something similar necessary for the smaller private ones? Householders, with a little ingenuity, not infrequently secure light by running flex from their house supply into their shelters, but, as the *Electrical Review* has pointed out (November 1, 1940), this practice is apt to prove dangerous—especially in view of the damp conditions often prevailing—unless done under expert supervision. Where alternating current is available, the reduction of voltage to a low value in shelters by local transformers has everything to recommend it.

I am reminded by several I.E.S. members that during daylight hours there *is* a **simple visible signal** that an air raid is in progress available to everyone. A police officer wears his gas mask in front whilst a raid is on, but slung behind his back during the "all clear." This is quite a useful indication if one happens to meet a police officer, though it loses much of its value in very wet weather, when capes are worn, and close inspection may be necessary to determine the whereabouts of the "bulge," and it is not readily applicable in the darkness. The Prime Minister, in the House of Commons recently, recalled the suggestion that a red flag should be shown. In Maidstone a method has apparently been adopted whereby official spotters display a visible signal during the danger period.

The damage sustained by so many churches during the past few months, involving shattering of many **old stained glass windows**, has raised the question of procedure in their post-war reconstruction. Glass of great beauty or historic interest, carefully preserved, will, no doubt, be reinstalled. But, otherwise, is it necessary that one should aim at perpetuating the old conditions? Or should one rather select glass admitting rather more light? In many old churches the obscurity arising from the opacity of the glass, and sometimes deeply coloured and also deeply encrusted with grime, is a genuine drawback. In **Liverpool Cathedral** the authorities have announced their intention, after the war, of adopting lighter glass, though preserving the original design. I have a very vivid recollection of Ely Cathedral, where the use of clear glass for the upper windows (mostly out of sight of the worshippers) is exceedingly effective in enabling the beauty of the interior to be seen.

A letter from our old friend, Mr. A. P. Trotter, recalls the experiments, made during the last war under his supervision as President, on **the candle-power of parachute flares.** The special photometer designed to make possible tests of the extremely high but fugitive candle-power from these flares (the duration of light being usually of the order of half a minute) is of considerable interest. A brief reference to these experiments was made in the course of the meeting devoted to "Photometric Reminiscences" early in the present year. They were described fully in the *Illuminating Engineer* (November, 1918, p. 253).

During recent months I have had some further experience of several problems mentioned recently in these columns ("Light and Lighting," Oct., 1940, p. 168)—the **obliteration of station name-plates** and the use of **protective netting for windows of public vehicles.** Name-plates have been only very imperfectly restored (and still more imperfectly illuminated) on many country stations, making night journeys in unfamiliar localities something of an adventure. A good deal more might still be done, with perfect safety, to reveal such names, especially where they are protected by an overhead roof or canopy. In regard to the other problem, I notice that in some instances a small uncovered aperture is being now provided on some windows of buses protected by webbing—an undoubted convenience to those who like to trace the stages of a journey by night.

I also notice that **bus conductors** on certain lines are now provided with very serviceable **portable torch-lights** to enable them to inspect tickets and provide change. This is evidently quite a feasible step, though, perhaps, impracticable to apply universally. It must make their task very much easier—though admittedly the amount of light now furnished in public vehicles is very much better than it was at one time.

The general replacement of glass by **opaque material in shop-windows** provides new opportunities. Certainly the loss of space for window display is a grievous one. If, however, owners of shops have to revert to the limitations of merchants in the Middle Ages they might in some degree copy their methods by making fuller use of the opaque areas for artistic display. Instead of presenting the public with blank walls, or with a perfunctory notice of "Business as Usual," they might make use of arresting pictorial treatment, altered and renewed at intervals. I have in mind a bookshop in my vicinity which has been so treated, and with good results, judging by the frequent clusters of people round these windows.

My attention has been drawn to the statement that in certain areas "**luminous lamp-posts**" are being installed. This refers to the use of coatings of white material which makes the posts "stand out" well in the dark. It has been stated that the material is phosphorescent, but I rather question whether, for all-night use, there is much advantage in the use of truly phosphorescent substances outdoors, unless the stimulus can be periodically renewed.

On the other hand, fresh white paint does stand out in a most remarkable way. For physiological reasons, it has a trick of appearing to become brighter as one approaches close to the object treated, so that a certain spectral impression of "phosphorescence" may be produced. In addition, the fact that such paint has a certain amount of gloss is an advantage, as it reflects light straight back to the user when illuminated by torches and headlamps.

I see that in Berlin efforts have been made to make **house numbers easier to find** in the darkness, either by the use of large white cardboard letters or by adopting luminous paint. "Direction figures," consisting of dark green figures embedded in shining white stones mounted in front of the house door, have also been introduced. Efforts are being made to incorporate phosphorescent material in the light cement, but apparently without very promising results. It seems possible, however, that what the inventors have in mind here is fluorescent material which could be continuously stimulated by a small screened source of ultra-violet energy.

I have been shown a newspaper cutting recording the use of a **photometer to check compliance of motor headlights with the Lighting Order,** by the police in Bedfordshire. This is certainly a sign of enterprise. There should be no serious difficulty in applying such a test, as the illumination to be measured (2.5 ft.c. at 10 ft.) is not inconveniently low. An instrument suitable for this purpose was described in "Light and Lighting" a few months ago (Oct., 1940, p. 164).

The Illuminating Engineering Society (U.S.A.)

Notes on Transactions (December, 1940).

NEWS: Attention is drawn to the new regional boundaries of sections of the society and portraits of the eight new regional vice-presidents are reproduced. Lighting schools are being developed in various areas. In New York a "technical forum," a new development, is announced. A report on night traffic accidents, issued by the National Safety Council, stresses the importance of adequate lighting as a means of combating the upward trend in street fatalities experienced in 1939. During that year there were 19,500 persons killed at night, as compared with 13,100 in the daytime—a total of 32,600. The importance of a scientific analysis of street accidents is pointed out. Reference is made to a new 100-watt fluorescent lamp furnishing 4,400 lumens. The source yields white light and is five feet long. The report of the general secretary draws attention to a rapid increase in membership, which now totals 2,890. The number has nearly doubled since 1934 (during 1930-34 there was a marked fall owing to the depression). Throughout the past three years, however, the total income has remained almost stationary, in the vicinity of 50,000 dollars.

CONTRIBUTIONS: *Sensation of Warmth as Affected by the Colour of Environment, F. C. Houghton, H. T. Olson, and J. Suciu.* Experiments were undertaken to determine whether any justification exists for the belief that certain colours give rise to "a warm environment." Records of temperature and tests of subjects enclosed in an experimental room lent no support to this impression. *Effects of Classroom Lighting upon Educational Progress and Visual Welfare of School Children, by M. Luckiesh and F. K. Moss.* The paper describes experiments conducted over three years, the conditions of lighting being correlated with educational progress and welfare of pupils in the fifth and sixth grades. It was concluded that improved lighting definitely increased educational progress, though the relation between lighting and visual efficiency was less evident. *Prediction of Lighting Performance of Plastic Mould Designs by Experimental Models, G. R. Baumgartner.* Describes the prediction of results by the aid of paper models and the use of special photometric apparatus in order to obtain curves of light transmission, etc.

Bactericidal Ultraviolet Radiation and its Uses, H. C. Rentschler. For the purpose of these tests a special integrating ultraviolet meter, which responds only to the effective bactericidal radiation, was devised. Some main conclusions derived from experiments on air-born bacteria are summarised. Ultraviolet generators of bactericidal radiation are discussed. In conclusion, practical uses of such radiation in meat preservation, domestic refrigerators, bakeries, nurseries, etc., are reviewed.

War-time Street Lighting by Gas

Hamilton Town Council has approved the recommendation of its Street Lighting Committee to extend street lighting in the town by the installation of 150 emergency fittings on lamps at cross roads. At present 293 gas lamps, chiefly on main roads and omnibus routes, have been converted.

The County Borough of Dewsbury Gas Department has more than 1,000 street lamps in use in war-time lighting schemes.

Nelson Street Lighting Committee has approved a scheme for extension of a modified street lighting system. About 540 gas lamps are to be converted.

St. Helens Corporation is including all secondary roads in its war-time street lighting scheme. Another thousand gas lamps are being converted, and *Eccleston,* which is supplied by the Gas Department, is also installing modified street lighting.

Street Lighting in India.—About 40 per cent. of the gas sold in Calcutta and in Bombay, according to the reports of the Oriental Gas Company, Ltd. (Calcutta) and the Bombay Gas Company, Ltd., is used for public lighting. The Bombay Gas Company has obtained a renewal of the public lighting contract for a period of eight years, from March 1, 1940. This entails the lighting of 8,721 lamps with 24,142 mantles.

Literature on Lighting

(Abstracts of Recent Articles on Illumination and Photometry in the Technical Press)

I.—GENERAL PHYSICS AND RADIATION.

1. Fading of Coloured Textiles.

A. H. Taylor. Magazine of Light, IX., No. 8, pp. 22-23, October, 1940.

A discussion is given on results obtained by fading tests with various light sources on a large number of dyed textiles. In general the shorter waves are largely responsible for fading, although the interposition of window glass does not greatly decrease the resultant fading from sunlight. The effect of temperature begins to be marked at above 150° F. Ordinary humidity does not appear to affect materially the rate of fading of many specimens. A water-cooled mercury lamp is suggested as a source to be used for standardised fading tests. C. A. M.

2. The Transmission of Infra-Red Light by Fog.

J. A. Sanderson. J. Op. Soc. Amer., Vol. 30, No. 9. pp. 405-409, September, 1940.

Measurements of transmission of infra-red radiation of wavelengths from 1 to 12 through 0.244 km. of foggy atmosphere show that the transmission is non-selective with wavelength. A. E. S.

3. Transmission of Infra-Red Radiation Through Fog.

P. N. Smith and H. V. Hayes. J. Op. Soc. Am., Vol. 30, No. 8,pp. 332-337, August, 1940.

Experiments were carried out over Boston Harbour, and over the sea from a point at Chatham (Mass.) to find the relative transmission through fog of radiation of three wavelength bands, (i) Visible and near infra-red, (ii) Infra-red up to about 3 μ, (iii) Infra-red above 3 μ. The authors avoid the use of " visibility " through the fog, or physical sampling of particles to determine the type of fog, because of the doubtfulness of such methods. It is shown that wavelengths above 3 μ are definitely transmitted when there is no measurable visible light transmission. A. E. S.

4. Theory of Subtractive Colour Photography.
III.—Four-colour Processes and the Black Printer.

J. A. C. Yule. J. Op. Soc. Am., Vol. 30, No. 8, pp. 322-331, August, 1940.

This is a continuation of work previously reported in J. Op. Soc. Am., Vol. 28, pp. 419-430, 1938, and Vol. 28 pp. 481-492, 1938. In this section the use of the black printer, both to increase maximum density of the film, and to supply the grey component, is described theoretically, and methods of making ideal black printers are given. It is also shown that dark colours other than black can be used for the fourth printer. A. E. S.

5. Method of Obtaining Long Optical Paths.

H. D. Smith and J. K. Marshall. J. Op. Soc. Am., Vol. 30, No. 8, pp. 338-342.

Methods are given for obtaining a long optical path through gases or liquids, which are particularly suitable when the fluids are available in columns of restricted length. A. E. S.

II.—PHOTOMETRY.

6. A Simple Portable Standard of Brightness.

British Standard Specification BS/ARP 52. December. 1940.

An instrument, providing a rough check on brightness values used for A.R.P. purposes is described. It utilises a translucent white screen forming one side of a box which contains an electric lamp controlled by a rheostat. A scale enables the brightness of the screen to be adjusted to 0.02, 0.04, 0.1, and 0.05 equivalent foot-candles. Coloured translucent screens, to facilitate comparison with the brightness of other coloured surfaces, are provided. J. S. D.

7. Photoelectric Measurement of Scale Marks and Spectrum Lines.

G. R. Harrison and J. P. Molnar. J. Op. Soc. Am., Vol. 38, No. 8, pp. 343-347, Aug., 1940.

A new type of all-electric network for photometric purposes is described, using an electron multiplier, which can be used rapidly to indicate the peak in a light impulse. In particular it has been used to improve a measuring engine for the measurement of scale marks and spectral lines. Densities at points on a plate as little as 20 microns apart can be compared. A. E. S.

8. The Use of Step Weakeners in Photographic Photometry.

G. E. Moore and H. W. Webb. J. Op. Soc. Am., Vol. 30, No. 9, pp. 413-414, Sept., 1940.

Describes the calibration and use of a five-step weakener. A very carefully controlled quartz mercury arc is used to give a constant source of radiation, making calibration simple and rapid. A. E. S.

9. Lighting Terminology.

H. Long. El. Rev., Vol. CXXVII., No. 3284, p. 367, Nov. 1, 1940.

Summarises definitions of lighting quantities, and explains the definitions in relation to engineering practice. R. G. H.

10. Colour Theories and the Inter-Society Colour Council.

H. P. Gage. J. Soc. Mot. Pic. Eng., Vol. 35, p. 361, Oct., 1940.

Summarises the fundamentals of colour theory and describes the work of standardising nomenclature that has been proceeding on the Inter-Society Colour Council, which links the various interested bodies in the U.S.A. R. G. H.

IV.—LIGHTING EQUIPMENT.

11. A New Negative Carbon for Low-Amperage High-Intensity Trims.

W. W. Lozier, D. B. Joy, and R. W. Simon. J. Soc. Mot. Pict. Eng., Vol. 35, p. 349, Oct., 1940.

Describes the development of the high-intensity arc to apply to theatres whose equipment permits only low current working. Higher screen brightnesses and better colour quality are obtained with the use of the new negative carbon. R. G. H.

12. New Equipment and Appliances.

Anon. Elect., 125, p. 270. Nov. 22, 1940.

Details, with photographs, are given of new lighting equipment now available. One item is a fitting for a 5 ft. fluorescent. lamp and the other is a pendant artificial daylight louvred fitting. C. A. M.

V.—APPLICATIONS OF LIGHT.

13. Light and Architecture.

Anon. Am. Illum. Eng. Soc. Trans., pp. 663-668. Sept. 8, 1940.

Some representative architectural lighting schemes are described, with photographs. J. S. S.

14. Effects of Illumination on Reading Efficiency.

M. Luckeish and F. K. Moss. Am. Illum. Eng. Soc. Trans., pp. 703-707, Sept. 8, 1940.

An attempt has been made to estimate the effect of change in illumination on ease of reading by measurement of the electrical potentials set up by the movement of the

eyes. Data, obtained from oscillograph records, on the speed of reading, the number of fixations of the eye, and the duration of these fixations indicate a considerable and consistent increase in ease of seeing when the illumination upon the work is raised. J. S. S.

15. Relighting a Large Industry.

J. M. Smith. Am. Illum. Eng. Soc. Trans., pp. 692-702, September, 1940.

A description is given of the relighting of the works of General Electric Company of America, begun in 1935. Much use has been made of mercury vapour lamps, both normal and fluorescent. A number of widely differing installations are described in detail. J. S. G.

16. Windowless Factories.

W. J. Austin. Magazine of Light, IX., No. 8, pp. 33-34, and 49. October, 1940.

The merits and demerits of windowless factories are discussed, with particular reference to lighting requirements. It is claimed that windowless factories lend themselves more easily to uniformity both in lighting and in temperature requirements. C. A. M.

17. Base Safety Lighting on Accurate Accident Data.

A. L. Pryor. El. World, 114, p. 999, October 5, 1940.

The author describes a method for recording road accident data in a way which enables best use to be made of the data for provision of safety measures. It is claimed that, although the scheme has been in use only a short while, it has already shown the value of good lighting for road accident prevention. S. S. B.

18. Protective Lighting for Industrial Plants.

J. A. Summers, D. M. Warren. Magazine of Light, IX., No. 8, pp. 35-43, October, 1940.

Suggestions are made on the exterior lighting of factories in order to prevent sabotage. C. A. M.

19. Fluorescent Lamps.

R. W. Morris, C. L. Amick. Magazine of Light, IX., No. 8, pp. 8-14, October 9, 1940.

Numerous photographs with details are given of the successful use of tubular fluorescent lamps in factories, stores, and a library. C. A. M.

20. Fluorescent Lamp Applications in the Home.

Myrtle Fahsbender, R. G. Slauer. Am. Illum. Eng. Soc. Trans., pp. 669-691, September 8, 1940.

It is claimed that the colour distortion occurring with the latest fluorescent lamps is so small as to be unnoticed after a few weeks. Various installations are described, and the merits and demerits of the lamps when used for domestic purposes are discussed. J. S. G.

21. Fluorescent Lamps in the Textile Industry.

J. M. Shute. Magazine of Light, IX., No. 8, pp. 15-20, October 9, 1940.

The successful application of tubular fluorescent lamps to the manufacture of textiles is dealt with in detail, with numerous photographs. C. A. M.

22. Answers to Technical Questions.

"E.O.T." Elect., 125, p. 259, November 15, 1940.

The relation between various units in illumination work is briefly discussed. C. A. M.

Mr. W. J. Jones appointed Director of E.L.M.A.

Last month we recorded the retirement of Mr. C. W. Sully from the position of director of the Electric Lamp Manufacturers Association. We now learn that he is to be succeeded by Mr. W. J. Jones. No appointment could have been better deserved nor more widely acclaimed. Readers of this journal are well aware of his versatile and successful work whilst in charge of the Lighting Service Bureau. It should be of great benefit to the E.L.M.A. to have as director one who combines expert knowledge of lamps and lighting with considerable organising skill and the essential capacity for making friends—not only within his special circle but in all sections of the lighting industry. Mr. Jones has been associated with the the Illuminating Engineering Society from its early stages, acting on numerous committees, on the council, and as vice-president. We congratulate him heartily on his new position and wish him every success.

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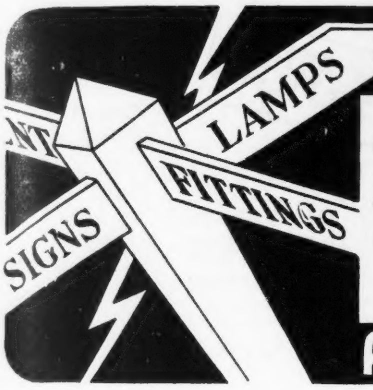

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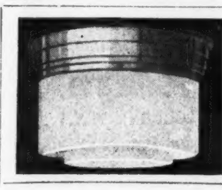

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